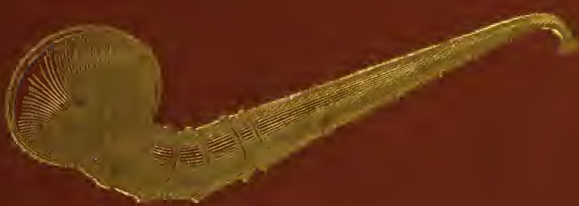
HELPS TO HEAR.



CAMPBELL.

HELPS TO HEAR.

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WITH ILLUSTRATIONS.

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PREFACE.

The object in presenting the following pages, is to offer to the profession and the general public, a brief practical review of the subject which is discussed, and upon which so little has been written.

So far as possible, technical details and unnecessary elaborations have been avoided. The desire has been rather to give in a clear, concise, semi-popular form the important facts connected with the topics considered. For many obvious reasons this has seemed desirable, and with this feeling it is left with the indulgent reader.

J. A. C.

ST. LOUIS, MO., Jan., 1882.

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HELPS TO HEAR.

INTRODUCTION.

Which is the greater affliction, blindness or deafness? is a question which is sometimes discussed. Certainly either is a calamity, but observation teaches, that while the deaf are less helpless, the blind are, as a rule, the happier of the two. At first thought this statement may seem strange, but the fact remains, and a satisfactory explanation may be offered. When one loses his sight he becomes helpless, and must depend upon some one else for assistance in all of his life relations; his very existence hinges upon this; and hence the blind surrender themselves most completely to their surroundings, and, accepting the situation, find their happiness within themselves. While the deaf man seeing with sharpened eyes, all that is going on

around him and hearing nothing, becomes suspicious and morbid—and hence unhappy. Again the blind receive a universal sympathy, which is not extended to the deaf, this is consoling and helps them to bear their misfortunes with becoming philosophy and resignation.

The deaf are to be found in every community, and their various troubles and annoyances are well-known. With this fact in mind, it is my purpose to present here a brief review of the mechanical helps to hear, for it is a subject which seems not only not well understood, but also very generally neglected. The scattered little, that has been written in this direction, together with the evident practical importance of the subject, would seem to make this all the more a necessity, and hence desirable. The physician will frequently be applied to for advice and aid in these cases, and, it being a subject so entirely out of the every day practice, the information given, if given at all, is usually vague and unsatisfactory. This is not much to be

wondered at, for even the standard text books on the ear and its diseases are sadly deficient in this direction, many of them barely making a brief mention of the subject.

It is not the intention to consider either the pathology or the therapeutics of deafness, but to discuss the subject entirely, as an obstruction to be overcome by mechanical appliances, as by an ear trumpet, etc. Notwithstanding this it would be very unwise as well as unscientific to advise the use of an ear trumpet, or other appliances to aid defective hearing, before making a careful examination of the patient to determine whether it is a suitable case, for the condition may be one, which depends upon some obstruction or complication, which can readily be removed. In such a case treatment should be advised, which point will be considered farther on.

What spectacles are to the eye, the ear trumpet should be to the ear; but while the adaptation of glasses to correct the optical defects of the eye, may

be considered as one of the complete sciences, with but little more to be desired, the science of Acoustics is still far from furnishing the help required, in the application of its principles to aid defective hearing. Or have the sanguin anticipations, which the recent discoveries and advances in this branch seemed to justify, been, as yet, in the least realized. But it is certainly within the range of reasonable probabilty, that the next few years will witness many developments in this direction.

CHAPTER I.

THE ANATOMY AND PHYSIOLOGY OF THE EAR, A BRIEF REVIEW—SOUND. WHAT IT IS AND A FEW OF THE LAWS WHICH GOVERN IT.

While neither the limits nor scope of this little work will permit any extended remarks upon the anatomy and physiology of the organ of hearing, a short review of the same is essentially necessary, before the subject can be properly introduced and understood.

The parts concerned, briefly given, are the auricle, or external ear. Extending inward, from an opening in this, runs a little canal, the meatus auditorius externus, or outer canal, about one inch long. At the bottom of this canal, and closing it, is stretched the membrana tympani or drum-head; this consists of a delicate membrane about as thick as the thinnest writing paper. Behind the drum-head is found a small cavity, the tympanum, contaning the ossicula auditus, or little chain of three bones, which articulate

with each other, and extend from the membrana tympani across the tympanic cavity to a little oval opening, the fenestra ovalis, on the internal tympanic wall. The first bone, the malleus is inserted in the layers of the drum-head. It articulates by its rounded head with the next bone, the incus; and this in turn joins the stapes or stirup bone, the base of which is attached to the membrane covering the fenestra ovalis.

Back of the tympanum are small open spaces in the bone, the mastoid cells; and from the anterior portion of the tympanic cavity runs a little canal, the eustachian tube, about an inch and a half long, connecting this cavity with the throat, or posterior nasal space. Next comes the internal ear or labyrinth, situated in the petrous portion of the temporal bone; this is the most important part of the organ of hearing, for it is in this that the terminal filaments of the auditory nerve are expanded.

Finally comes the auditory nerve itself, taking origin in the base of the brain.

The following figure, representing a central sectional view of the left ear, will show the parts and their relation to each other, as above described.

Having thus briefly described the parts concerned in the act of hearing, let us consider for a moment

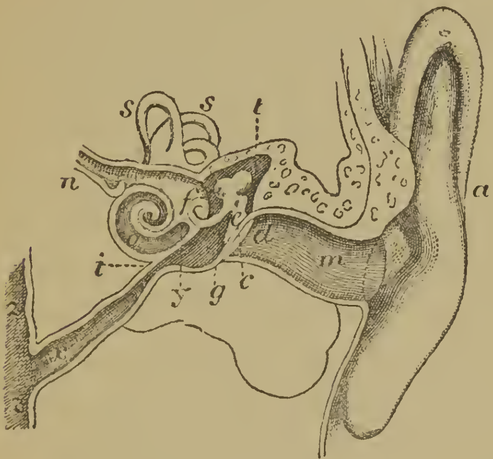

FIG. 1. CENTRAL SECTIONAL VIEW OF THE LEFT EAR.

a, auricle; *m*, external canal; *d*, drum-head; *c*, insertion of malleus in membrana tympani; *e*, articulation of malleus and incus; *f*, base of the stapes inserted in the fenestra ovalis; *t*, tympanum; *g*, incus joining stapes; *i*, tympanic opening of the eustachian tube; *x*, opening of eustachian tube in throat; *z*, posterior part of throat; *n*, auditory nerve; *s*, semi-circular canals; *o*, cochlea.

their physiology; or in other words how and why we hear. To make this more clear we will refreshen our memories with a few facts in acoustics.

Sound is the result of air vibrations, and it is sub-

ect to certain well known, definite and fixed laws. According to Helmholtz there must be at least sixteen vibrations in a second, before these vibrations are recognized as sound. This gives the lowest tone. The pitch of the sound depends upon the number of vibrations in a given time. If sixteen vibrations per second gives us the lowest tone, then thirty-two vibrations in the same time would give its octave, and sixty-four vibrations the second octave, etc., until we reach 38,000 vibrations per second, or about eleven octaves, which, according to the same authority, is the upper limit corresponding to the highest recognizable tone. This may be accepted as the ordinary range of hearing, although it has been conclusively proven, that some lower and much higher tones have been recognized by different observers.

The velocity with which sound moves depends upon certain modifying circumstances. At $\frac{1}{2}°$ (centigrade) above the freezing point, it moves 1089 feet per second, increasing about two feet per second, for every degree above this.* Its velocity likewise depends upon the medium through which it is conducted; thus it moves

*Tyndall on Sound.

through water four times as rapidly as through air; through the fibres of pine wood ten times as fast, and through iron seventeen times as fast. Sound is propagated through the air in undulating waves; the breadth of each wave is known as its samplitude. The intensity of the sound depends upon the extent of its amplitude.

As sound diffuses itself through space, it diminishes in intensity, growing fainter and fainter inversely as the square of the distance, until it fades away into silence.

Sounds from different sources have each their own characteristic and distinguishing properties, known as their quality. This depends not only upon their souree, but also upon the commingling of other more rapid vibrations from the same source, known as overtones.

CHAPTER II.

PHYSIOLOGY OF THE EAR—HOW SOUND IS PERCEIVED—THE PART EACH PORTION PLAYS IN THE PROCESS—THE AURICLE; ITS COLLECTING FUNCTION; INFLUENCE OF ITS ANGLE—AUDITORY CANAL—MEMBRANA TYMPANI—OSSICULA—INNER EAR;—AUDITORY NERVE—TWO PATHWAYS FOR SOUND TO REACH THE NERVE.

But sound only becomes sound through the medium of the ears, and having examined this organ, as well as the essential principles of sound involved in the act of hearing, it only remains for us to show how these vibrations are received by the ear; and are recognized as sound.

The sound wave first strikes the auricle or outer ear, which is presumed to have some collecting function; although this latter statement has been questioned, for in ancient times when the barbarous punishment of cutting off the ears was in vogue, it was observed, and placed on record by writers of note, that the absence of the external ear did not seem to

interfere very much, if any, with the hearing. It is very probable though, that these observers were much in error, and that a careful test of the hearing, made by a competent authority, both before and after the removal of the auricle, would have revealed some difference then, as it does now. Still it is a* well known fact that birds have no external ear, yet they possess a very good and often times quite acute sense of hearing. On the other hand it is equally well known, that the large and movable external ears of many animals, as in the horse, the mule, the dog, etc., influence their hearing power very much; not only aiding them in determining the direction from which the sound comes, but also making it more distinct, acting like a trumpet, and thus catching and concentrating the sound. We know too that if the open hand be placed behind the ear, in this way enlarging, as it were, the size of the external ear, it gives quite a perceptible increase of the hearing power.

With these facts before us we can understand how the angle, which the auricle makes with the head, might influence the hearing to some degree. It has

*Five Senses of Man.

been supposed by Bernstein,* that the angle of 40° was the one most suitable for hearing purposes. Some other theories have been advanced as to the office of the external ear, but surely the above well known facts warrant us in believing, that it certainly has some collecting function, what ever other offices it may have.

We follow the sound wave on. After striking the external ear, it is conducted through the external meatus, which has likewise its special acoustic function. If we look at the external ear, and the canal leading from it to the drum-head, we shall see, that they together are essentially a little funnel shaped canal, with an expanded collecting mouth-piece, the auricle, acting in some degree like a trumpet. For this reason the sound waves, in passing through the auditory canal, are more or less concentrated, because the sound passing through such a tube is in a measure condensed; for sound like light may be condensed, reflected and refracted.

This canal is likewise a tube closed at one end by the drum-head. Such a closed tube has the power of increasing certain sounds very much. This acoustic

property of tubes, closed at one end, increasing sounds, is known as resonance—and it has been proved by Helmholtz, that the external auditory canal has a special resonant action, by virtue of which certain sounds are further increased.

The sound wave, having passed through the outer canal, strikes the drum-head, which is set in motion, and the vibration is transmitted by this means to the little chain of bones before described, and through which it is conducted to the membrane, which covers the fenestra ovalis and articulates with the base of the stapes. This in turn is set in motion, and by this means and through this pathway, the sound wave is continued on to the inner ear or labyrinth where the filaments of the auditory nerve are distributed.

The labyrinth has likewise its special function. It is divided into three parts, the semi-circular canals, the vestibule and the cochlea. While the exact office of each of these three parts is not as yet definitely settled, it is accepted as a fixed fact that each part has its own peculiar function.

What the particular purpose is, which the semi-circular canals serve, has been a subject of considerable

dispute. There are three of these canals, forming rather more than half a circle, their three planes being nearly at right angles to each other; and for this reason it is most commonly supposed, that by them we distinguish the direction from which the sound comes.

By the experiments of Flourens and others, the semi-circular canals have also been shown to have an influence over the movements of animals, by controlling their equilibrium.

Goodsir concludes that, "The vestibule is that part of the organ, by means of which any sound, or series, or combination of sounds is heard merely as noise."

It has been conclusively proven by Helmholtz, Kolliker, Corti and others, that the office of the cochlea is to recognize the pitch of the sound. In it have been demonstrated three thousand little rods, the organs of Corti, of which Tyndall speaks as follows: "Finally there is in the labyrinth a wonderful organ, discovered by the Marchese Corti, which is to all appearance a musical instrument, with its cords so stretched as to accept vibrations of different periods, and transmit them to the nerve filaments, which traverse the organ. Within the ear of man, without his knowledge or con-

trivance, this lute of three thousand strings, has existed for ages, receiving the music of the outer world, and rendering it fit for reception by the brain. Each musical tremor, which falls upon this organ, selects from its tensioned fibres, the one most appropriate to its own pitch, and throws that fibre into unisonant vibration. Thus, no matter how complicated the motion of the external air may be, these microscopic strings can analyze it and reveal its constituents"*

We may thus divide the organ of hearing into two parts, recipient and conducting, which consist of the series of parts above enumerated. Any break or interference, in any of these links, will interfere in a greater or less degree with the hearing. But as will be readily understood, the auditory nerve and the nerve centres are the important parts of the auditory function; and as long as these remain intact, so long may sound be perceived, if by some means it is conducted to them.

There are two ways in which sound may reach the auditory nerve, either by the usual channel as above given, through the external ear, drum-head, ossicular,

*Tyndall, On Sound.

etc., or the sound vibration may be conducted through the bones of the head directly to the nerve itself. For instance, a vibrating tuning fork, with its handle placed at any point on the head, can be heard very readily, and likewise the ticking of a watch is very plainly perceived, when it is placed between the teeth. This is because the vibrations are conducted directly to the nerve of hearing through the medium of the cranial bones.

CHAPTER III.

MECHANICAL AIDS TO HEARING, TWO CLASSES—THEORY OF EAR-TRUMPET; ITS VARIATIONS AND MODIFICATIONS—SIMPLE—TIN JAPANNED—SQUARE—POCKET—DOUBLE-CURVE—TELESCOPIC—WALKING CANE—DIPPER SHAPE—MARTINEAU—HASWELLS—EAR OF DIONYSIUS—CONVERSATION TUBE—OTHER FORMS.

All mechanical aids to hearing are of value, either because they intensify the sound, and thus overcome some obstruction in the pathway of the ordinary conducting apparatus; or because they open up a way for the transmission of the sound, through the other channel—the bones of the head.

Under the first class, or those which intensify sound, or aid in completing a defective or obstructed link in the external or middle ear, we include all forms of ear trumpets, speaking tubes, artificial drum-heads and other mechanical apparatus adjusted on or in the external ear.

Under the second heading, or those which utilize

the bones of the head, as a pathway for the transmission of sound to the inner ear, are to be placed the now well-known Audiphone and Dentaphone, together with the modifications of the same, known as the Audinet, and the Osteophone. The first mentioned being the original instrument and originating in Chicago; the second being made in Cincinnati; the third in New York, and the last coming from Philadelphia.

EAR TRUMPETS.

The fact that sounds are intensified by passing through an ordinary horn or ear trumpet, is almost too well known to require discussion, but before considering the different forms of trumpet, a few words, by way of explanation, may not be out of place at this point.

It has been stated, that sound diminishes in intensity inversely as the square of the distance. But this is only true, when it is allowed to follow its usual course, uninfluenced by secondary or accidental circumstances.

According to Tyndall* sound is intensified in passing through a tube, because the lateral circles of diffu-

*On Sound.

sion of the undulating waves is prevented. And since sound like light may be reflected and condensed, the vibrations, in passing through a tube or funnel, are, for this reason, also reinforced and intensified. The following diagram Fig. 2, showing the condensation of the sound waves, will illustrate this theory of reflection and concentration.

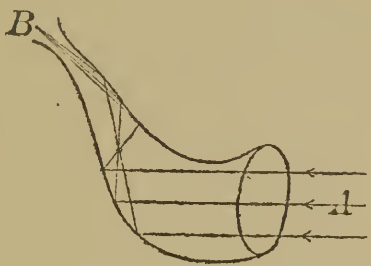

FIG. 2. THEORY OF THE EAR TRUMPET.

The vibrations proceeding from the direction, as represented by A, are collected by the expanded mouth-piece of the trumpet. They strike its walls and undergo a series of reflections from side to side, as illustrated by the diagram, and are finally brought to a focus at B, and are thereby rendered very much stronger and the sound louder.

This may be accepted as the explanation of the phe-

nomena of the ear trumpet, as far as it goes; but it must be confessed, that the complete explanation of the action of the hearing trumpet presents some difficulties.*

Keeping in mind these facts, together with the statements previously made concerning sound, will aid us somewhat in comprehending the essential principles, which make the ear trumpet of value.

Ear trumpets are of various forms; the size, angles, curves and shape in each are presumed to be most perfectly adapted in acoustic properties. We have the long; the double curve; the square; the telescopic; the Martineau and a host of others. These are all held in the hand, and are only variations of the same principle. In ancient and rural times the horns of animals were used, and in many cases they answer every purpose.

Many forms of ear trumpet have been devised and made from time to time; some having the addition of a vibrating membrane stretched across their calibre, which is presumed to possess some advantages. In fact almost every possible form has been exhausted by

*Deschanell, On Sound.

the suggestions of ingenious and persevering aurists.

The material from which the trumpet is made does not seem to be a matter of much importance. Wood, metal, glass, horn, rubber, etc., have been used. Neither does it influence the pitch nor intensity of the sound, but it very materially affects the quality of the

FIG. 3. SIMPLE EAR TRUMPET.

tone. While it is true that the walls of the trumpet itself are also affected by the sound, and are, in most cases, better conductors of sound than the air contained in the tube itself, still this fact does not assume a degree of sufficient practical importance, to influence very much a preference for one material over that of another. Some form of metal is most frequently used, as tin or white metal. Its advantages are that it is light, is easily worked and fills every requirement.

The simplest form of ear trumpet consists merely of

a funnel shaped tube, of varying lengths and sizes, as seen in Fig. 3.

The larger the expanded collecting end, and the longer the tube, the louder the sound will be. This was well illustrated by one of the most interesting of the experiments made by Mr. Edison during his researches on sound. He succeeded in conversing at a distance of one and a half to two miles, with no other apparatus than a few paper funnels. These funnels constitute the "MEGAPHONE,"* an instrument wonderful both for its simplicity and its effectiveness. There were two large funnels used, one for each ear; they were six feet eight inches long, and twenty seven and a half inches in diameter at the larger end. Each funnel terminated in a flexible tube, the end of which was placed in the ear. The conversation was carried on through a speaking trumpet, which did not differ materially from the ordinary one, being only a little longer and having a little larger bell-mouth. With this instrument conversation has been carried on, at a distance of one and a half to two miles, in the ordinary tone of voice. A low whisper, uttered without using

*Prescott's, The Speaking Telephone.

the speaking trumpet, was distinctly audible at a distance of a thousand feet; and walking through grass and weeds, was heard at a much greater distance.

But this form of trumpet, because of its length and shape, is unwieldly and inconvenient. To obviate this, and for other reasons, trumpets are made with various curves and angles, and the sound, instead of passing

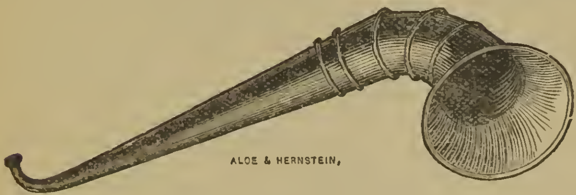

FIG. 4. TIN JAPANNED EAR TRUMPET.

through in a straight line, is deflected from angle to angle, and thus the same length of tube may be obtained, with about the same effect, in a much more convenient shape. The first form of curve may be represented by what is known, as the Tin Japanned Tube, as seen in Fig. 4.

It is, as its name would indicate, made of japanned tin. It is quite light and very effective, but as may be readily seen, is open to the great objection of being very conspicuous when used.

SQUARE EAR TRUMPET.

The square ear trumpet may be considered as practically the long trumpet bent twice upon itself, with square angles, and is represented by Fig. 5. It, like

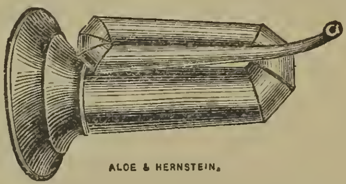

FIG. 5. SQUARE EAR TRUMPET.

most of the other forms, is made in different sizes, but as a rule, as the size of the instrument decreases so is its power diminished, and what is sacrificed to looks must also be lost in strength.

A smaller, but similarly shaped instrument, Fig. 6, has been made, so that it can be taken apart and carried in the pocket, and for this reason is called the

POCKET EAR TRUMPET.

This is often a matter of great convenience, and therefore this form has that much in addition to recommend it. It is a question though, whether its power

is not diminished in some respects, by this form of joint.

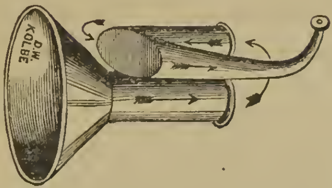

FIG. 6. POCKET EAR TRUMPET.

DOUBLE CURVE EAR TRUMPET.

In the Double Curve Trumpet, the angles, instead of being square, are rounded, which has been presumed to be more suitable for the accurate deflection of the

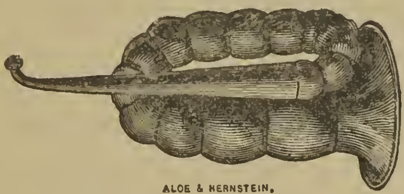

FIG. 7. DOUBLE CURVE EAR TRUMPET.

sound waves passing through. Its shape may be seen in Fig. 7.

TELESCOPIC EAR TRUMPET.

The telescopic trumpet Fig. 8, is made in gradually

diminishing sections, which can be closed up like a telescope. This form, while it may not be quite so useful as many others, it is convenient, because it can be shut up and carried in the pocket, occupying but small space.

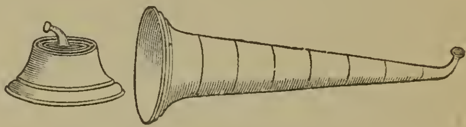

FIG. 8. THE TELESCOPIC EAR TRUMPET.

Trumpets have been made in the shape of walking canes, as seen in Fig. 9. They are more unique than useful, and have never been very extensively used, as they are much inferior to most of the other forms.

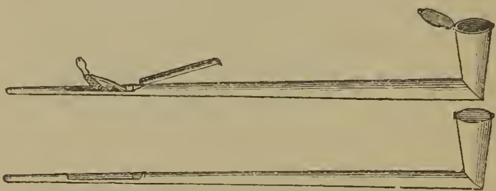

FIG. 9. THE WALKING-CANE TRUMPET.

All of these trumpets, which represent a certain class, concentrate and intensify sounds very much, and therefore aid the hearing in a marked degree. The disadvantage, which some of them have is, that there is

a certain reverberatory effect, which changes the character of the sound more or less, and sometimes renders it rather unpleasant, as well as confused, though this effect is not noticeable to the same degree by all who use them, as some seem to be more sensitive to it than others. It is not usually so marked in another series of trumpets, which are known as the

DIPPER TRUMPET.

This consists of a large dipper shaped bowl, or collecting chamber, which is covered by a perforated disk; this dipper bowl has a hollow handle, which is extended in a curved line inside of the bowl, nearly to the bottom, to a point, where the sounds received are collected in the focus, as it were, and by this arrangement, thus concentrated, are reflected into and through the handle of the instrument to the ear.

The following cut will represent this form of instrument:

This form of trumpet is often very admirable in high degrees of deafness. It allows the voices of several persons to be understood at the same time, which is not always so with the ordinary trumpet. From its

size it is more suitable for the lecture room or church; in this case the bowl may be placed upon the floor or

FIG. 10. DIPPER TRUMPET.

on a stool, and the sound conveyed to the ear by means of a flexible rubber tube, which may be concealed under a coat or shawl. It may also be represented by what is known as the MARTINEAU HEARING HORN, and the EAR TRUMPET of HASWELL.

MARTINEAU HORN.

The MARTINEAU HORN was named after Harriet Mar-

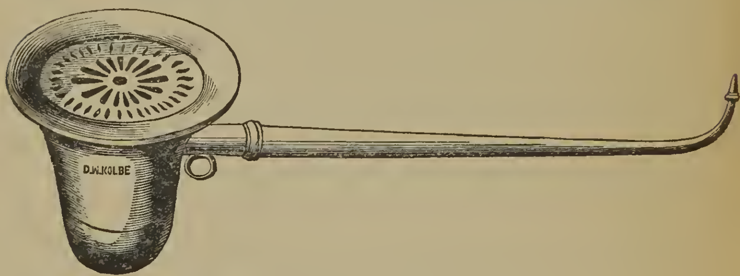

FIG. 11. MARTINEAU HEARING HORN.

tineau, who was very deaf and used it. Fig. 11, is a

cut of the original Martineau Trumpet. It has been quite extensively used in England.

A modification and presumed improvement of the above is HASWELL'S EAR TRUMPET, as seen at Fig. 12. It is the trumpet which is used by the Rev. Dr. Haswell and his son, missionaries to Burmah, both of

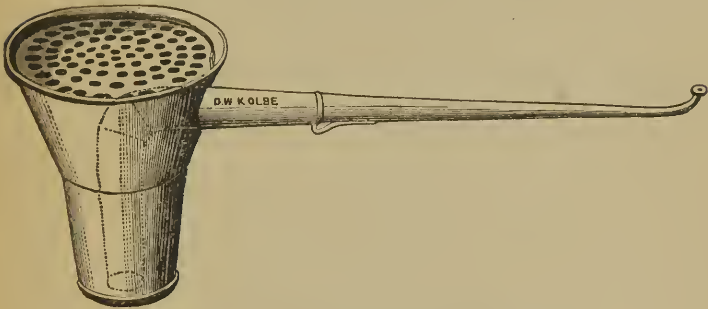

FIG. 12. HASWELL'S EAR TRUMPET.

whom are very deaf. After having tried about every form of ear trumpet, they give it the preference over all others. They relate, that with it they have been enabled to catch the last faint whisper of a dying man, and that, by its aid, they can converse with several persons at the same time.

Under this grouping will also come that which is known as the EAR OF DIONYSIUS FIG. 13. It is on the

dipper principle. It rests on an iron base, which stands on the floor. It is on a swivel, so that the mouth can be turned in any direction. The collecting

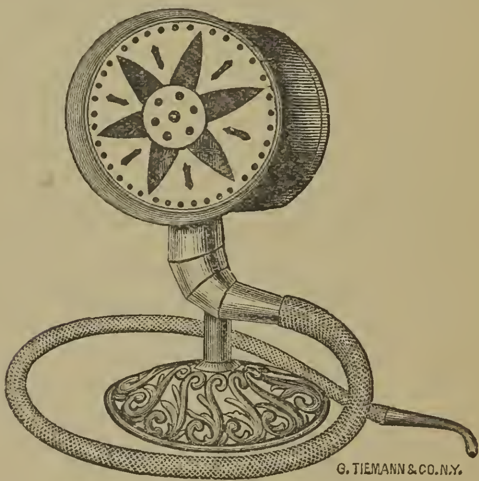

FIG. 13. EAR OF DIONYSIUS.

chamber stands about fifteen inches from the floor, and is about nine inches in diameter. From it extends a long tapering flexible tube or neck, ending in the usual ear-piece. It is intended for very deaf people to hear general conversations in a parlor, or for use at lectures, church or concerts. In this sense it is intended to be stationary, and not to be carried about.

It would be admirably adapted for the use of a judge on the bench, or as a fixture in the assembly room, in the home of a very deaf person.

CONVERSATIONAL TUBE.

The conversational tube Fig. 14, is, as its name implies, for conversational purposes. The principle involved is exactly the same as in the trumpet. It consists of a flexible tube of varying lengths from one to

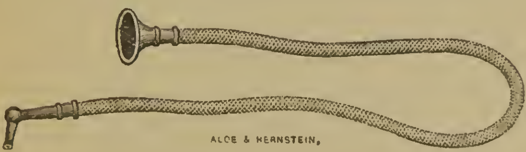

FIG. 14. THE CONVERSATIONAL TUBE.

three feet long. It is usually made of spiral wire, covered with rubber and over-spun with mohair or silk. It has sometimes a gradually diminishing calibre of the tube itself, and again it is merely a simple straight tube. It terminates with a little ivory or rubber tip, which fits in the opening of the ear. It is probably the instrument most frequently used by the deaf, in conducting every day business. The conducting tube being flexible, it is more convenient, less unsightly and

answers for general conversational purposes better than the trumpet; for when not in use it can be hung around the neck, under the coat, as is most frequently done. The speaker talks directly into the receiving end of the tube; for this reason it is of little use for any other purpose, as for hearing general conversations, or a single speaker talking, when any distance from the mouth of the tube.

The following cuts, Fig. 15, taken from a French

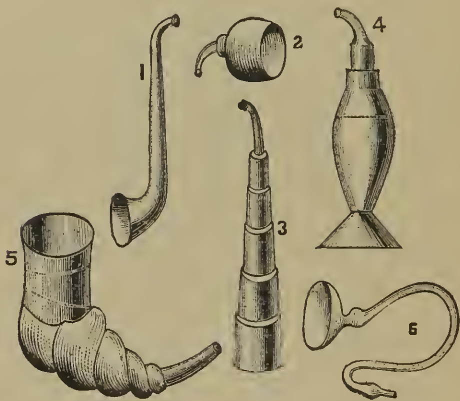

FIG. 15. FRENCH EAR TRUMPETS.

work on acoustics, while they, together with those given, by no means exhaust the long list of suggested

forms, they will give a good idea of the ear trumpet and its various modifications.

No. 1, is the plain trumpet. No. 2, is a diminutive form, its manner of use will be very evident. No. 3, is a telescopic trumpet. No. 4, has membranes of gold-beaters skin stretched across, which are claimed to render the sounds less confused, but not louder. No. 5, is a prolonged spindle shaped shell into which membranes are also introduced. While No. 6, is KOENIG'S ACOUSTIC TRUMPET which also has a membrane introduced into it.

These thin membranes, stretched across the calibre of the tube, are peculiarly susceptible to impressions from aerial vibrations, and are presumed to modify them favorably. According to the experiments of Regnault, it was found that these membranes were affected at distances greater than those at which the sound could be heard.

The question may now be asked, which of the above is the best, or has the most advantages to recommend it. The answer will depend entirely upon the case and upon the purposes for which it is intended to use it. No unvarying rule can be made regulating the

choice of a special form of ear-trumpet, most suited to any particular case, direct trial alone will best determine this.

The principle involved in each of the different forms of ear-trumpet, and the advantages claimed for them, have been given as they have been described. From these descriptions, some idea can be formed as to the trumpet, which would fill most of the requirements of any specified case.

CHAPTER IV.

The deaf sensitive to anything conspicuous—Devices to obviate this—Auricles of Itard—Invisibles—Silver cornets—Apparitor auris—Artificial drum-head; its history—Cotton pledget—Hassenstein's—Toynbee's—Lucae's—Gruber's—Theory of its action—When of use.

The deaf are, as a rule, very sensitive over their infirmity, and hence dislike any instrument which is conspicuous, or makes this condition more apparent; for this reason many other devices have been invented, which seek to conceal this fact, as much as possible, among which are to be numbered the following:

AURICLES OF ITARD.

The Auricles of the celebrated Itard are little flattened cup-shaped arrangements, which fit into the ears, and are kept in place by a spring passing over the head, which spring can be worn concealed under a cap or bonnet, or with ladies, by the hair. They are

sometimes of much service, but can not usually be worn for any length of time, because of the rustling

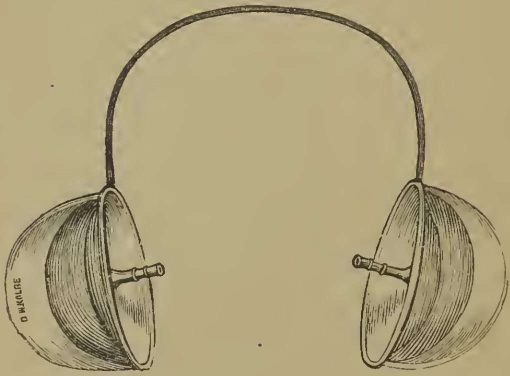

FIG. 16. AURICLES OF ITARD.

noise they produce, and on account of the irritation which they create in the external ear.

INVISIBLES.

A small metallic arrangement to be worn concealed

FIG. 17. INVISIBLES.

in the outer ear, and called "INVISIBLES," FIG. 17, has been before the public as an instrument of great value, as an aid to hearing. It is assumed to assist the hear-

ing by keeping open the collapsed, flabby walls of the external auditory canal. While such a condition is possible, it is not usual, and I have yet to find a case where this instrument has been of any marked use. Theoretically it looks well, but practically it is one of the best failures ever invented.

SILVER CORNETS.

An instrument similar to the above is known by the

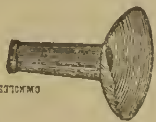

FIG. 18. SILVER CORNET.

name of Silver Cornets, Fig. 18. They are somewhat larger, and have this in their favor to recommend them, though they are essentially the same.

The Apparitor Auris, as represented by Fig. 19, resembles the cornet. It is claimed for it that by the extending out of the canal, as seen in the illustration, the tube is thus lengthened, and collects sounds better, and that it has the additional advantage that it prevents the diffusion of sounds. They come in pairs, one for each ear.

ANGLE OF THE AURICLE.

As has been mentioned before the angle which the auricle makes with the head is presumed to influence

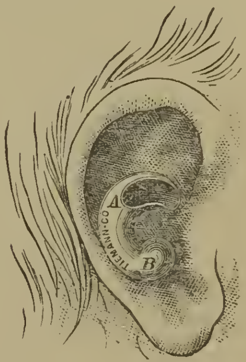

FIG. 19. APPARITOR AURIS.

its collecting power. In keeping with this theory the Otaphone was invented. It consists of a small clamp to fasten behind the ear, causing it to project farther from the head. It will often be found to be an instrument of much practical utility.

ARTIFICIAL DRUM-HEADS.

Another very valuable mechanical aid in certain forms of defective hearing is the Artificial Membrana

TYMPANI. This is said to have been employed more than two centuries ago, not as an aid to hearing, but rather as a protection for the diseased or perforated drum-head. As early as 1640 Marcus Banzer used a tube, covered by a bit of pig's bladder, for protection to the exposed ear, when the drum-head was totally or partially lost by ulceration, etc. Modified in various ways it was used for this purpose by different aurists, from time to time after that. In 1841 an American gentleman from New York, first made known the fact to Dr. Yearsley, of London, under whose care he was, that his hearing was much improved by moistening a small wad of paper, and then introducing it into the external meatus, down to the drum-head. This fact was given to the profession, and from it originated the various membranæ tympanorum now in use. Yearsley found that small moistened pellets of cotton were more to be preferred, and records numerous cases, with perforated drum heads, where the hearing was very defective, which were benefitted by this means in a marked degree.

Hassenstein has invented a small metal pronged arrangement which holds such a cotton pledget, and by

which it can be introduced into the ear down to the

FIG. 20. HASSENSTIEN'S INSTRUMENT.

drum-head, and, being so small, can be left in the outer canal unseen.

TOYNBEE'S ARTIFICIAL TYMPANI.

In 1853, without seeming to know that it had previously been suggested, Toynbee invented an artificial drum-head. It consists of a thin disk of vulcanized rubber, in the centre of which a fine silver wire, a little more than an inch in length, is attached, terminating in a small ring, by which the instrument can be removed.

FIG. 21. TOYNBEE'S ARTIFICIAL DRUM-HEAD.

This has been also improved upon from time to time. The silver wire instead of being fastened in, according to his original method, has been made to screw in, which is an improvement. As the silver wire is very apt to irritate the delicate structures of the drum-

head, and vicinity, which are indeed sometimes super-sensitive because diseased, Lucae, of Berlin, devised an artificial drum-head, which is a little soft rubber

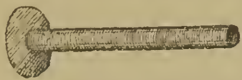

FIG. 22. LUCAE'S ARTIFICIAL DRUM-HEAD.

tube about 2mm. in diameter, at the end of which a small rubber disk is attached, by a solution of gum arabic. As the tube is soft and flexible, it is introduced by means of a metal or wooden probe, passing into the rubber tube.

GRUBER'S ARTIFICIAL DRUM-HEAD.

Among the latest and simplest of the forms is that of Gruber of Vienna. It consists merely of a small rubber disk, in the centre of which a fine silk thread is attached. It is introduced by means of a specially contrived angular forceps, which allows it to be placed in position, and on being withdrawn leaves it there, with the fine thread hanging out of the external meatus. This thread may be cut off, so as to render it entirely concealed. It has fewer objectionable features

than most of the other forms. It fills about all the requirements, and from its simplicity and convenience, has much to commend it. A special apparatus for its manufacture has been made for it, consisting of a small circular, sharp punch, a thin sheet of rubber, with the needle and necessary silk thread, all of which is contained in a little hard rubber cylinder, which is convenient and compact.

FIG. 23. GRUBER'S ARTIFICIAL DRUM-HEAD.

The above will represent the forms of artificial drum-heads most in use. Why and how they help defective hearing has been a subject of considerable discussion. Toynbee very much modified the views which he originally entertained concerning the manner in which the artificial drum-head had produced its effects. In later years he finally summed up* as follows, the conditions of the ear in which it had been efficient:

1. "Disconnection of the incus and stapes, the membrana tympani being entire, but the tensor tympani

*Toynbee on the Ear, Hinton's Supplement.

ligament, or the mucous membrane of the tympanum being relaxed. [Consult Fig. 1.]

2. "Partial or complete absence of the long process of the incus, the membrana tympani being entire.

3. "Disconnection of the stapes and incus, the membrana tympani being perforated, and the tensor ligament or mucous membrane of the tympanum being relaxed.

4. "Partial or complete loss of the long process of the incus, the membrana tympani being perforated, and the ligament of the stapes being relaxed."

In a recent article on the subject Hackley* recapitulates that "the cases which seem to have been benefited by the use of Toynbee's artificial drum-head, are those where the eustachian tubes are pervious, and where extensive damage had not been done the ossicles by the previous inflammation. Moreover benefit is not always immediate and in my experience the improvement in hearing, has often been proportionately greater for the voice than for the watch."

Lucae claimed, that the improvement follows because

*Archives of Otology. Vol. VIII p. 230.

the fluids of the inner ear are brought under greater pressure.

In short they are presumed to aid by remedying a relaxed condition of the articulating ossicula, and at times by modifying and equalizing the drum-head tension, which has been diminished or interfered with by perforation or disease. Hence it is only adapted to certain forms of defective hearing, only to be determined by direct examination and trial.

The fact that there is and has been such a great diversity of opinion in reference to the value of the artificial drum-head shows that its status is far from being settled, and that its virtues are not uniform. Each form as above described has had its earnest advocates.

Dr. Hackley, as above quoted, says that, "The best instrument that we at present have for this purpose is Toynbee's artificial membrana tympani;" while Dr. C. H. Burnett affirms* that "there has never been but one useful kind of artificial drum-head, and that is the cotton-pellet of Yearsley." This form is likewise the

*American Journal of Otology. Vol. II. p. 14, 1880.

one most commended by Troltsch, who in the latest edition of his text-book says, "After having become acquainted with Hassenstein's little cotton forceps (Fig. 20) I have almost completely abandoned the use of the artificial drum-membrane proper. A number of patients wear the cotton plugs for years with constant relief of their deafness and material benefit as to the suppuration."

In a very recent article* on the subject by Dr. H. Knapp, the acoustic and therapeutic importance of the cotton-pellet drum-head is very ably discussed, and a number of interesting cases are given, in the light of which this latter excellent authority also adds his testimony in its behalf.

*Archives Otology. Vol. X. No. 1 p. 60.

CHAPTER V.

AUDIPHONE — DENTAPHONE—AUDINET—OSTEOPHONE—DESCRIPTION AND ILLUSTRATION OF—DISCUSSION OF THEIR VALUE;—REPORTS OF EXPERIMENTS—HISTORICAL; NOT A NEW DISCOVERY.

The preceding chapters will represent the first class ot mechanical helps to hear, or those used in or upon the external ear; it remains now for us to consider those included under the second heading—The Audiphone, the Dentaphone, the Audinet and the Osteophone.

It has been stated in a former chapter, that if a watch is placed between the teeth, its ticking can be heard, because the sound vibrations are transmitted through the teeth, bones of the head and thence to the auditory nerve. The Audiphone in its application takes advantage of this fact. It consists essentially of a diaphragm of hard rubber, thin and elastic, presenting a collecting surface of about one square foot, something like a fan

in shape, with a handle for holding it. The upper edge is placed under the upper central incisor teeth, and by pressure upward upon the handle, or by means of a cord attachment, the instrument is bent up and made to present a convex collecting surface to the speaker, and hence a concave face to the person using it. The sound waves strike the collecting surface and are transmitted from it to the teeth, and from the teeth to bones of the head, and through them to the nerve of hearing as before indicated, and in this way they become audible.

FIG. 24. RHODES' AUDIPHONE.

The original AUDIPHONE is the invention of R. S. Rhodes of Chicago, who lost his hearing from disease of the middle ear. He accidently discovered, that he

could hear his watch when it was placed between his teeth, and then commenced a series of experiments, which finally resulted in the invention now known as the RHODES' AUDIPHONE, as seen in Fig. 24, which

FIG. 25. AUDIPHONE IN TENSION, THE PROPER POSITION FOR HEARING.

represents the natural position of the instrument when not in use, and in which position it may be carried, by gentlemen, by attaching it to a hook or button on the vest, or inside of the coat. It is in this shape also that it may be used as a fan, which as it will be seen, it very much resembles.

When in use it is made to assume a certain curvature, by means of a cord arrangement, which passes through a ring on the handle, which fastens the cord and is thus held in place. By this means its convex-

ity may be fixed at any desired degree. This arrangement is shown by FIG. 25, which represents the Audiphone in tension ready for use. The silken cords,

FIG. 26. AUDIPHONE IN POSITION DURING USE.

which are attached to the upper edge, pass down as a single cord, and run through the ring on the handle; by means of this the desired tension may be obtained, and the cord fastened at that point by a wedge attachment.

It will be found necessary to regulate the tension most suited for each person, which point, individual experience alone will determine.

Fig. 26, gives the position of the Audiphone during use. It should be held loosely in the hand with its upper edge placed in easy contact, by a slight pressure against one or more of the upper teeth. Usually the "eye teeth," give the best results, but a little practice will soon determine which is the best for hearing purposes. The lower teeth should not be allowed to come in contact with the instrument, and it should not be pressed beyond the point of tension, at which it has been adjusted. Nothing should touch the instrument between the hand and the teeth, as this would deaden the vibrations and interfere very much with its action.

FOLDING DENTAPHONE.

Because the original Audiphone from its shape and size, is somewhat unhandy to carry about, an improvement on it has been made, by the American Dentaphone Company in Cincinnati, called the Folding Dentaphone. It is essentially the same instrument with folding wings, by means of which it may be closed up to occupy a much smaller space. When opened the wings are held in position by a rubber cord, which

is attached to a pin in the handle. Its convexity is maintained by placing the edge against the upper teeth, and then by means of pressure upward of the han-

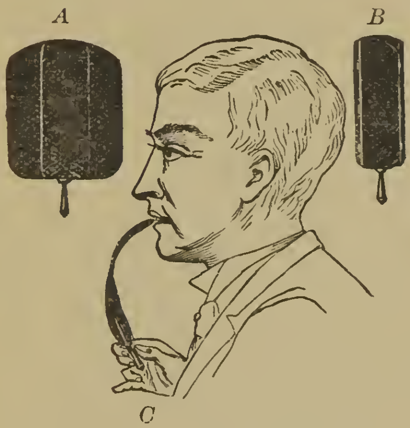

FIG. 27. FOLDING DENTAPHONE.

A represents the Dentaphone when used as a fan; *B* shows it folded up, so that it may be carried in the pocket or otherwise, when not in use; *C* represents it in position during use.

dle, the flexible middle is made to bulge outward. The instrument and the manner in which it is used, will be seen in the illustration, Fig. 27. It is made in two sizes, the smaller for conversational purposes, nine by seven and a half inches, and for lecture and concert use, eleven by eighteen inches.

THE AUDINET.

The Audinet is a modification of the AUDIPHONE, having a second smaller disk behind the first. Fig. 28, shows the position of the instrument in use.

FIG. 28. AUDINET IN POSITION DURING USE.

It has a series of cord attachments, which when drawn down and fastened, by means of a ring on the handle, bend the two disks in opposite directions, and thus secured, the instrument is ready for use.

The following diagram, Fig. 29, will show the manner in which the silk cords are attached to the smaller

disk. Two pieces of cord are used, which terminate in a knot secured to the tassel. The cords are endless

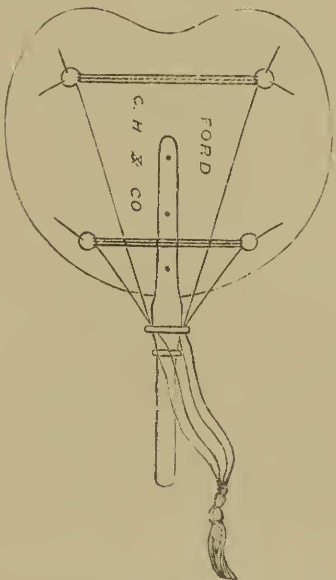

FIG. 29. AUDINET, MECHANISM OF ITS CORD ATTACHMENT.

except at the tassel, crossing three times from opposite rings, through which they slide, when drawn into position for use.

JAPANESE OTACOUSTIC FAN.

At the present day no invention, improvement or novelty can long remain the especial property of any one locality, but, if of value, its merits meet universal recognition, and it is almost immediately appropriated all over the world, either in its original form or enlarged upon or modified to meet special requirements of people or surroundings. The Audiphone is no exception to this. In late years, the Japanese have shown remarkable aptitude both in adopting and using new ideas. Some three years ago an institution for the education of the deaf and dumb was organized in Tokio, the first of its kind in Eastern Asia. This institution has the support of the first men of Japan including royal patronage, and excellent reports have come to us concerning it. They have contrived an instrument there, fashioned after the Audiphone, which is identical with it in principle but differing from it somewhat in form, and in the material from which it is made. Their sound-transmitting fans are made of lacquered sheets, which are said to answer the purpose even better than the vulcanite, of which the ordinary

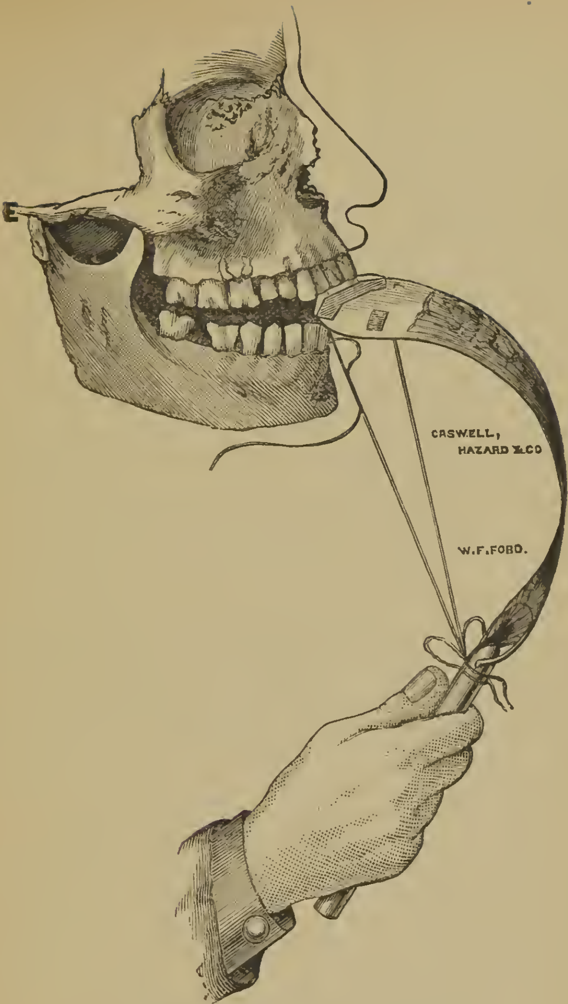

FIG. 30. JAPANESE OTACOUSTIC FAN.

Audiphone and its various modifications are constructed. This hearing-fan is now known as The Japanese Otacoustic Fan.

Within the past year this instrument reached this country and the Japanese Consul at New York, Mr. Kimihira, presented it to Dr. Samuel Sexton for experiment; and after a careful trial of these fans (there are several varieties), this gentleman* speaks very favorably of them, stating that they are equal to, if not more satisfactory than any sound-transmitting fan yet produced; and possess the advantage of being considerably cheaper.

The instrument and the manner of using it is illustrated by Fig. 30, which represents a lateral view of the Fan held in position and adjusted for use, in contact with the upper teeth. At *E* is located the commencement of the external auditory canal.

After numerous experiments with the Otacoustic Fan, Dr. Sexton found that its value was enhanced by the addition of an instrument, which he devised and has named the DENTAL SOUND TRANSMITTER. This

*Medical Record, Sept. 10, 1881.

consists of a small plate of German-silver folded upon itself, and so constructed, that its free edges may be pressed apart and slipped over the upper edge of the fan; and in this way it may be applied to even the ordinary paper-covered bamboo fan. The elasticity of the two plates of the instrument is sufficient to retain it securely in its place on the fan. The part which comes in contact with the teeth is slightly turned up, which affords a more perfect adaptation to the teeth than the edge of the fan, and likewise protects the fan from moisture and from injury by the teeth.

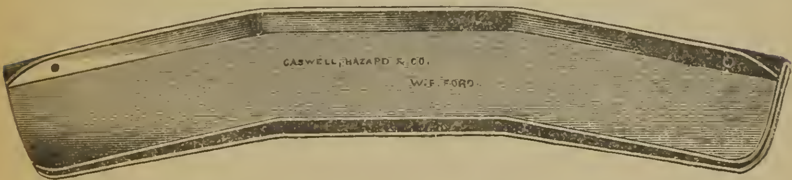

FIG. 31 DENTAL SOUND-TRANSMITTER.

The dental sound-transmitter is made of German-silver folded upon itself; the free edges are pressed apart to receive the upper edge of the fan. The edge opposite the above, where the metal is folded is turned up at an obtuse angle to fit the teeth. There are two holes in this edge for the attachment of cords, which tie to the handle, thus producing and maintaining the proper curvature or audiphone tension of the fan.

The position of the dental sound-transmitter and the manner of using it is seen in Fig. 30, although in this

cut it is somewhat exaggerated in size. This devise is represented by Fig. 31.

OSTEOPHONE.

Because the Audiphone is conspicuous, and obscures, to a certain extent, the features of the person using it, and because it requires the constant service of at least one hand during its use, Dr. C. M. Thomas*, of Philadelphia has devised another modification of the Audiphone, which he designates as the Osteophone, which appropriate name is proposed as a general term for all appliances intended to aid the hearing, by conveying articulate sounds to the ears, through the medium of the cranial bones. The description of the instrument is as follows: "A large receiving diaphragm is attached, in an arched form, to a rod of wood or metal. The rod is bent in the form of a pipe-stem, one end of which is to be held firmly between the teeth as a pipe is held, thus enabling the user to listen to sounds about him, and, at the same time leaving his hands free for other occupation. The diaphragm being be-

*Philadelphia Medical Times. Feb. 28, 1880.

low and away from the face, it is comparatively inconspicuous."

The advantages claimed for the above are surely obvious, and in certain cases would be very desirable.

DENTAPHONE.

The original Dentaphone, is a novel instrument, involving the same acoustic principles as the Audiphone, and is applicable to the same class of cases. It consists of a little chambered box about the size of a large watch, with an open side piece similar to the microphone attachment to the telephone. In this little box is a vibrating diaphragm, through the centre of which passes a silken cord, about twelve inches long. To the other end of the cord is attached a small plate of wood or tooth piece. To use this instrument, the wooden tooth-piece is placed between the teeth, and the instrument, which is held in the hand, is directed toward the speaker, and the silken cord is drawn tense. The tones of the speakers voice are received upon the vibrating diaphragm and are conducted through the cord to the wooden tooth-piece,

and thence to the teeth, bones of the head and to the nerve of hearing.

This instrument is small, weighs but one ounce and a half, and from its size can be easily carried about in the pocket. As mentioned before it is applicable to exactly the same class of cases as the Audiphone, but according to the results obtained from my own experiments with it, it is of very much less value.

It may be mentioned that artificial teeth may interfere to some extent with the successful application of the Audiphone, as they cause a break in the pathway of the sound, and this interferes more or less with its transmission.

If the auditory nerve is intact, and no obstacle prevents the transmission of the sound through the teeth and cranial bones, the Audiphone and its various modifications will often be of much service and aid certain forms of defective hearing very materially. But the fact that it has gone before the public through the medium of the public press and journals, as a miraculous restorer of the deaf, without qualification or restriction, has made it one of the greatest disappointments of the day. It should be remembered,

however, as Turnbull very properly remarks* in discussing this question, that the word "deaf" as ordinarily accepted is in reality quite vague and uncertain in its meaning, for it in no manner indicates the degree of diminished hearing power. To say that a man is deaf, may mean either, that he does not hear well, or that he is very hard of hearing, or that he can hear nothing. For this reason the above mentioned writer divides deafness into partial, profound, and absolute. It is only in the first two classes that any improvement should be expected, for in the absolutely deaf no sound can be heard, and no form of instrument can be of any service. Hence it will be seen, that to expect any improvement from the Audiphone, or similar instrument, the case must be a suitable one. And thus many of the reports of failures of the Audiphone to meet the sanguine expectations of the deaf, which were indeed justified by the unqualified assurances, or at least the inadvertantly implied claims of the inventors, may arise from the fact that they have been used without discrimination. Dr. E. T. Ingalls states, in the *Chicago Medical Journal*, that Messrs. Sharp & Smith of

*Archives Otology, Vol. VIII., p. 375.

Chicago had tried the Audiphone in 150 cases, and not a single one of them was benefited. It would be interesting to know just what proportion of these were suitable cases.

The merits of the Audiphone have been thoroughly tested and reported upon by several well known and competent authorities. Among them Dr. H. Knapp, of New York, after careful experiments with the instrument gives* a tabular list of fourteen suitable cases; from which it seems that all but two of the cases were benefited in varying degrees by it, but in every case, the improvement was less with the Audiphone than with a dipper-shaped ear trumpet; the difference in fact being largely in favor of the trumpet.

The following is a copy of his report, 1 represents the acuteness of hearing for the ordinary voice without any instrument. The increase by the instrument is represented by the proportions of 1.

*Archives Otology, Vol. IX., p. 1.

No.	Without an Instrument.		With the Audiphone.		With the EarTrumpet.	Disease.
1	1	:	5	:	7	Chronic aural Catarrh
2	1	:	1.5	:	6	" " "
3	1	:	1	.	3	" " "
4	1	:	5	:	8	" " "
5	1	:	5	:	7	" " "
6	1	:	3	:	20	" " "
7	1	:	2.5	:	10	" " "
8	1	:	2.7	:	13.3	" " "
9	1	:	1.5	:	4	" " "
10	1	:	2	:	4	" " "
11	1	:	1.5	:	1.4	Otit.med.pur.Chronic
12	1	:	3	:	12	Nervous deafness

Recently Edmund Treibel, superintendent of the Royal Asylum for the deaf and dumb, in Berlin, made a thorough trial of the Audiphone in his institution, and in a report of the same* sums up the result as follows:

"I will simply add that in the course of these experiments, I made use of three different dentaphones, and always obtained precisely the same results.

*Archives Otology, Vol. IX, 4

"I may safely state, therefore, that where deaf mutes are concerned, the dentaphone, in its present condition, can not be put to any practical use, not even as a means of advancing articulation. Also judging from experiments I have made upon perfectly healthy persons, I am inclined to doubt that the instrument can give any trustworthy assistance to any one whose hearing is in the least defective."

Notwithstanding these reports, which come to us with the stamp of high authority, there are certain cases where this instrument is of use, which fact I have more than once demonstrated to my entire satisfaction. Though my experiments with it in the main correspond closely in the results obtained, with those given by Knapp. It is not to be denied that there are many authentic cases, where the use of the Audiphone was sufficiently successful to be very satisfactory to the person using it, though this result is far from being general.

There is likewise a certain class of cases where the Audiphone may be of service in another way. For instance, in deaf mutes where the trouble has existed from infancy, as is usually the case, and has been ow-

ing to some obstruction in the pathway of the external conducting apparatus, and the auditory nerve itself still retains a diminished though appreciable portion of its original power.

When a nerve of special sense is unused for any length of time, it gradually begins to lose some of its perceptive power, and grow weaker. As for instance, it is seen in the eye, when one eye is affected with strabismus, and is no longer used with the other or straight eye. The result is that the vision of the deviating eye is gradually lost, producing what is known as *amblyopia ex anopsia*, or defective vision from lack of use. When the eye is straightened, and once more moves in harmony with its fellow eye, the lost vision will generally be gradually strengthened by this exercise, and frequently a large portion of its lost power may be eventually regained. And so it may be with deaf-mutes of the above mentioned class, where the auditory nerve still retains a certain diminished portion of its original power, weakened from lack of use. The person so afflicted does not know what *sound* means, but the Audiphone will open up a

new pathway for it, by which it may reach the nerve of hearing, which, under this stimulation, begins to gain a portion of its lost power, and to perceive and recognize the sensation we know as sound. In other words the instrument may be used as a medium for *sound education*. This proposition is by no means entirely theoretical, for it is fully borne out by such a case, which I now have under observation. The progress may be slow, but it is surely perceptible. [See illustrations of teaching deaf mutes with Audiphone, figs. 32 and 33.

Without going farther into historical description of the Audiphone, I will state that its value depends upon a principle long known and well understood by aurists for years gone by. And even as an instrument it is old, for as early as 1770 a translation of a book by Prof. Buchner, of Halle, appeared in London, entitled "An Easy and Very Practicable Method to Enable Deaf Persons to Hear."* And one of the few novelties of this book is the account where a partially deaf person was enabled to hear, by having a thin slip of wood touching his own upper teeth, and also those of the person speaking.

*Wild on the Ear.

FIG. 33. A CLASS OF DEAF MUTES LISTENING TO MUSIC FOR THE FIRST TIME.

CHAPTER VI.

POSSIBLE MECHANICAL OBSTRUCTION IN EXTERNAL CANAL —ON DRUM-HEAD—IN TYMPANIC CAVITY—IN EUSTACHIAN TUBE—PATHOLOGICAL CONDITIONS, ETC.

If the deafness depends upon some mechanical obstruction in the outer ear, or any where else, which could be easily removed, it would certainly be very improper to endeavor to remedy the trouble by means of an ear trumpet or any other similar apparatus. For this reason having now considered the mechanical aids to hearing, it seems proper to devote a few words to some of the mechanical obstructions, which may exist in the pathway of the sound conducting apparatus.

Among the first of these obstructions, may be placed a stopping up of the external canal. This may result from many causes; from any of the innumerable foreign bodies, which may become lodged there, such as beans, peas, beads, etc., or some forgotten bit of wool

or cotton placed there in some former attack of ear trouble, may be the offending body. Cases are on record where this condition of things, causing deafness, had existed for years undiscovered. Accumulations of dry and hardened wax may be the cause; for some unknown reason certain ears seem to be predisposed to this form of trouble.

The external canal may be partially or totally closed from inflammation in or near the canal; or by polypus; or by any of the many different forms of tumor growths. Exostosis may also close the canal. Sometimes the flabby walls of the canal will nearly close it. There have been many cases reported, where the external orifice of the canal was closed by the integument growing over it, these are congenital conditions.

Any of these causes may, in different degrees, interfere with the passage of sound through the external auditory canal—and may be regarded as mechanical obstructions capable of removal.

Most pathological conditions affecting the ear offer mechanical hindrance to the passage of the sound. The drum-head may be thickened from inflammation, or may contain calcareous deposits. There may be in-

flammation in the tympanic cavity, which may result in a thickening of its walls, or accumulation of mucus or pus in its cavity. There may be a stiffening or anchylosis of the little chain of bones; or there may be adhesions, the result of former inflammations in the tympanum. Or the eustachian tube may be closed by catarrhal inflammations. Any of these conditions, as well as diseases of the inner ear or nerve of hearing, may cause deafness in varying degrees, and must be resigned to the domain of therapeutics.

CHAPTER VII.

EXTERNAL AND SECONDARY AIDS TO HEARING—VISION, ITS GREAT VALUE—DISTINCTNESS—WHY SOME WORDS ARE HARDER TO HEAR THAN OTHERS—INFLUENCE OF ATTENTION—ECHO, ITS INFLUENCE ON HEARING IN LARGE ROOMS—VARIABLE HEARING.

There are several external and secondary aids to hearing, which while they can not properly be considered as mechanical helps to hear, in the sense in which we have discussed the ear trumpet, etc., still they do aid very materially, our comprehension of external sounds.

Vision.—The first, which we may consider, is the influence which vision has, and the help it gives in the act of hearing in conversation. Everyone uses his eyes more or less, when listening to a speaker; the expression of the face, the movements of the lips, the general bearing and gesture, are all carefully, though unconsciously noted. In proof of this, all of us will recall, how unsatisfactory it is to sit in church, or at a

lecture, with anything intervening between us and the speaker, to interrupt the view. A post, however small, or a neighbors hat or bonnet becomes a source of great, and sometimes almost unbearable annoyance. And we often fail to catch certain words, not because the sound is shut off, but because the sight is; for we will find that closing the eyes will have a similar effect.

If the eye helps them to see, who hear well, it truly plays a far more important part in the act, among the deaf or partially deaf. When any one of the special senses is lost, the deficiency seems to be, in a measure, made up by the development of greater strength in some other direction. Thus in the blind, the sense of hearing and that of touch are more acute than usual. And so in the deaf, we find that the sight is exceptionally sharp, and they use it with remarkable effect. They can understand a conversation very much better if they can see the lips of the speaker; and for this reason a man with whiskers covering the mouth is a deaf man's bane, because it conceals the movements of the lips. To show how far this may be carried, I will mention, that in a deaf and dumb institution, in Vienna, I saw pupils readily write the dictations of a

teacher, which they caught entirely by looking at the motions of his lips, they being unable to hear a sound. It may be stated also in this connection, that the teacher was beardless, and pronounced the words with great care and precision, which is very necessary, and brings us to a second external aid to hearing, and that is the distinctness with which words are pronounced.

Distinctness.—We all have among our friends those whom we can scarcely understand in conversation, on account of the mumbling indistinct or smothered manner in which they talk. If the hearing is a little defective, this fault becomes all the more apparent. A partially deaf person will understand a low tone distinctly spoken, much better than a loud word, which is mumbled or badly enunciated.

Certain sounds and words are heard much better than others. The vowel sounds are heard better than the consonants, and therefore the words containing them, and where they predominate will be heard better. According to Wolf, as quoted by Burnett, the broad sound of A is heard farther than all, being heard, pronounced at a certain stated intensity, 360

paces, O is heard nearly as far; while the sound Oo, is only heard 280 paces. The English A is heard 330 paces. I 340 and E 300 paces. The diphthong Ou, as in out, is weakest of all the diphthongs, being a little weaker than Oo. H is the weakest of the consonants, when pronounced with a vowel, it is lost at a distance of a few paces. Next in strength is B, Ba being heard further than Ha, B alone is heard at a distance of eighteen paces. The deeper the note the less effect it has upon the ear. The high notes are most valuable in this respect, as shown by Moos, though this is liable to exception. R with only 16 vibrations in a second is not distinguished farther than 41 paces. K and T stand next; they are both heard equally at 63 paces. S owing to its sibilant character can be heard distinctly at 173 paces. M and N unaccompanied by vowels are very weak.

From the above it will be seen why certain words may be heard better than others, depending upon the letters which compose it.

Attention, has also a great influence over the hearing power. A person may become so absorbed in thought, or in an occupation, that even the loudest

sounds may be entirely unnoticed. This listless inattention becomes habitual with some, and this conveys the impression to outsiders, that they are hard of hearing This obtuseness is not because they can not hear, but because they do not heed. The sound impression is properly transmitted through the usual external conducting links, but it fails to impress the nerve centres otherwise engaged or absorbed.

It is possible also, by an act of volition, to concentrate the attention on one sound or series of sounds, to the partial exclusion of other sounds, which go to make up a combination of tones or the blending chords of a harmony; for instance an operatic singer little heeds the bewildering confusion of the hundred voices around him, but attends strictly to his own part. Again we can, if we wish, voluntarily follow the alto, the tenor or any other single part of a quartet or a chorus; this is, as before, merely the result of concentrating the attention in one particular direction. This is a faculty which may be cultivated; and individuals differ very much in this respect. There are those who can keep track of all the conversation of an assembled company, while others hear only their

neighbor, or the one with whom they are personally engaged in conversation. Attention then aids the hearing. The increased acuteness of the hearing power during the act of listening, depends partly upon the influence of a concentrated attention, and likewise upon a voluntary action of two little muscles, the stapedius and the tensor tympani in the tympanic cavity, which are attached to the little chain of bones, and which by their action according to Lucæ, regulate in a measure their tension.

Echo.—In almost all large halls, there will be found some certain point where the speaker on the stage is heard with difficulty, where the effort of listening becomes tiresome. This is because the sound of the speakers voice, which strikes the walls of the room and is reflected back, interferes with the voice. This reflection is the secret of echo, and when the speakers voice and the echo blend on the same tone, the sound is strengthened, for we shall find that at certain distances the echo can no longer be distinguished from the original sound. But at a point just beyond this blending distance the two sounds will interfere and cause a perceptible indistinctness, and at times a

reverberation. If this effect is confusing to one who hears well, it is more evident indeed to any one with defective hearing. Hence the location of a seat in a large hall will influence the hearing. Certain halls are noted for this, and we say their acoustic properties are defective.

Every hall and every room has what is known as its "key note," or a tone of some certain pitch, which is heard better than every other tone. Public speakers are generally aware of this, and endeavor to regulate the pitch of the voice accordingly, for by so doing they can speak with much less effort, and they are heard with greater ease. Hence the pitch of the voice, in keeping with the above statement, influence the hearing.

The hearing may vary from time to time in the same person. This variable hearing, as a rule, depends either upon an aggravation or diminution, of some catarrhal irritation in the tympanic cavity, or eustachian tube; or it may have its origin in certain nerve complications.

It is an interesting fact that partial deafness may exist, even in quite a high degree, without being

recognized by the person so affected. It is indeed most frequently the case, that it is first noticed by ones friends rather than the person himself. This may be explained as follows: A watch is most frequently used as a test of the hearing power. The fartherest point from the ear, at which its ticking can be heard, is taken as the measure and limit of the hearing. Let us now suppose that a normal ear can hear a certain watch at the distance of fifteen feet. If the hearing power of such an ear becomes diminished so that it loses five or even ten feet of this measure there will still remain a very excellent hearing capacity; for a person who can hear the ticking ot an ordinary watch at a distance of even five feet, will have but little difficulty in hearing ordinary sounds and conversations, and will little dream that two-thirds f his normal hearing power are gone. In fact, it is only by acurate and careful tests, that such defects are revealed. There are indeed but few people, who have not some defect in one or both ears, whereby their natural range of hearing is to some degree lessened. It is very frequently the case that one ear hears better than the other; in truth, this is usually

so. If the hearing is acute in one ear, a very high degree of deafness may exist undiscovered in the other, unless it is brought to light by an accident; for instance, the person may lie on a pillow with the acute ear, and then, perchance, discover for the first time that there is something the matter with the hearing of the other ear. Or, when it is diminished to a certain point, he may realize, that he can not hear a person talking on that side as well as upon the other side. Or he will perhaps at last discover that he has unconsciously acquired the habit of turning his head a certain way toward the person talking—and then the reason for it flashes upon him.

CHAPTER VIII.

THE TELEPHONE THE WONDER OF THE AGE—ITS DISCOVERY—TELEPHONE OF REISS; THEORY OF ITS ACTION—TELEPHONE OF BELL—OF EDISON—DESCRIPTION OF THE TELEPHONE, AND THEORY OF ITS ACTION—ELECTRIC CALL BELL—LIGHTENING ARRESTER—MICROPHONE OR TRANSMITTER.

The telephone may justly be considered as the especial wonder of the day. Although it is only about four years since it was presented to the public, and a much less time since it began to have anything like a general introduction, it has spread with remarkable rapidity over the whole world, and is now so universally implored, that it may indeed be numbered with those every day affairs almost too common to cause wonder.

While the telephone in reality can not be regarded as an aid to hearing for the deaf, or as a means which overcomes or remedies defects in the organ of hearing, it extends the ordinary range of hearing so marvelously, that in this sense, it may indeed be considered

as a "Help to Hear," and for this reason, a short description of the instrument is introduced.

In a preceding chapter the essential characteristics of sound were presented. From it we learn, that sound is merely a succession of wave impulses, which move through the air, or other media, from a vibrating source to the ear. There is no actual transmission of anything from the sound source to the point where it is perceived, it is only the extension of ærial disturbance in wave form, which repeats itself, wave after wave, with a gradually diminishing intensity.

We have also learned, that every sound carries with it a certain combination of characteristic features, intensity, pitch and quality, which distinguish it from every other sound; and that this depends upon the rapidity, form and size of the vibratory waves. If we can by any means exactly reproduce these vibrations, exactly the same sound will be reproduced, and this is the secret of the telephone. "The previous development of the telegraph naturally suggested electricity as the agent to carry these vibrations from one place to another. To do this it became necessary to convert sound waves into electric waves, and *vice versa;*

and experiments looking to the accomplishments of that end were begun twenty years ago.

"The first successful experiments were made by Phillip Reiss of Fredericksdorf, Germany, in 1861. He argued, that if it could be found practicable to convert sound pulsations into electric pulsations and then to convert these pulsations back again into sound pulsations, the same effect would be produced as if the vibrations had actually been transmitted through the air." He devised an instrument for this purpose, which was the first invention to accomplish this result, and was the beginning of the telephone.

The telephone of to-day is not the result of a sudden or single inspiration, but has been reached step by step—the outgrowth and reward of patient toil and research. Its history from the beginning to the present time is full of interest, but is too lengthy to even epitomize here.*

The telephone of Reiss could only reproduce the pitch of the sound, and although a good beginning, it left much to be desired.

*To those desiring a complete and scientific exposition of this subject, Prescott's, "THE SPEAKING TELEPHONE, ELECTRIC LIGHT, ETC.," is to be recommended.

In 1874 Elisha Gray, of Chicage, invented a method of electrical transmission, by means of which could be reproduced at a distance, the intensity and quality, as well as the pitch of the sound, and was thus enabled to reproduce any number of tones simultaneously, without losing anything of their specific character.

The attention of the whole scientific world was now concentrated on this wonderful achievement. It seemed to develope all at once. In fact the question of priority in the invention of the speaking telephone has been very warmly contested. It appears that Alexander Graham Bell was working on the same problem that Gray solved, and apparently quite independantly of him. And by a strange coincidence, the similarity of results, which they attained at about the same time, was indeed somewhat remarkable. Their caveats being filed at the Patent Office on the same day, February 14th, 1876. Since then many different forms of telephone have been invented, differing from each other in detail of construction, but all embodying the scientific principles devised by Gray.

Among these the telephones of Bell, and of Edison,

are those most widely known and most generally in use in this country.

Each of the last named telephones have valuable points to recommend them for preference; and for a time the competition for public patronage was spirited, but by a recent arrangement of conflicting interests, the Bell Telephone Company, of Boston, now claim the sole and undisputed right to control the introduction of the telephone in this country. And as the Bell telephone is the instrument most generally used, and as it will fully illustrate the principles involved, a short space will be devoted to its description.

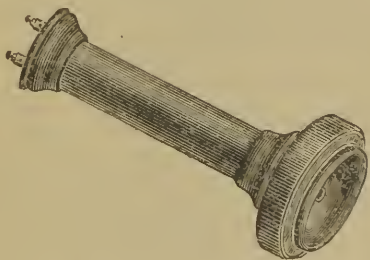

FIG. 34. THE TELEPHONE.

The telephone proper is the instrument illustrated in Fig. 34.

It consists of a cylindrical hard rubber case, about

six and one half inches long, with an expanded open end funnel-shaped mouth-piece; the case containing a disk, a coil of wire and a magnet. The essential features of the telephone are a thin disk or diaphragm of iron, japanned to prevent it from rust, and a powerful permanent magnet, with a soft iron core at one end, which is surrounded by a coil of fine insulated wire. The diaphragm is placed at the end of the instrument, behind an opening in the expanded mouth-piece, and is clamped at its edges between the two surfaces of hard rubber, formed by the funnel shaped end and the cylindrical stem of the instrument, these parts being screwed together. The magnet is so placed, in relation to the diaphragm, that the end of the soft iron core comes within about 3-100 of an inch from the disk, or as near as it can be placed without coming into actual contact when the disk is vibrated by the voice. The two ends of the coil of wire, which surround the soft iron core, are carried along the inside of the handle and terminate in binding screws, by means of which, the outside connecting and conducting wires may be attached. At the end of the handle

there is also a ring, by which it may be hung up when it is not in use.

FIG. 35. SECTIONAL VIEW OF THE TELEPHONE.

FIG. 35, is a sectional view of the telephone, which will show the several parts, just described, and their relation to each other.

The theory of the telephone and the operation of the instrument is as follows: We will take for example a wire one mile long, with a telephone as above described, attached to each end. When a person speaks into the mouth-piece of one telephone, its disk is caused to vibrate with a varying degree of force. All the peculiar characteristic features of the sound are thus transfered to the vibrating diaphragm. Its particles vibrate with a complexity of movement, which depends upon the peculiarities of the sound wave from which it is derived.

It will be remembered, that the vibrating disk is placed quite close to, but not in contact with the extremity of the steel magnet; it becomes therefore, for this reason, itself a magnet by induction; and, as it vibrates, its magnetic power is constantly changing, being strengthened when it approaches the magnetic core, and enfeebled as it recedes. Now when a magnet moves in the neighborhood of a coil of wire, the ends of which are connected together, an electric current is developed in the coil, whose strength depends upon the rapidity with which, and the distance through which the magnet moves. In the telephone then as the

disk moves toward the coil, a current is induced in the latter, which traverses the whole length of the wire connecting it with the distant instrument. As the plate recedes, another current with the reversed sign follows the first, and so on. While the intensity of these currents depends upon the rapidity with which the plate moves, it is also largely influenced by the fact, that the plate does not retain a constant magnetic strength throughout its excursions.

These currents, thus generated, pass along the connecting wire and circulate around the wire coil of the distant telephone. There they modify the magnetic relations between the steel magnetic core and the iron plate, in such a way, that, by its attraction and repulsion, varying as the impulse of the electric wave varies, the disk of the distant telephone is made to vibrate in precisely the same manner as the other disk, and, consequently to reproduce the same sound.

And thus it is accomplished the conversion of sound waves, which move at the rate of about 1,100 feet in a second, diminishing rapidly in intensity, inversely as the square of the distance, into electric waves

whose action is for all practical purposes instantaneous, moving through copper wire at the rate of nearly 300,000 miles per second—and finally the reconversion of these electric impulses into sound waves again, which are identical in character to the original sound.

A simple instrument of this kind at each end of an ordinary wire, like that used for the telegraph, furnishes all that is absolutely essential for speaking communication between two points thus connected. For practical use, however, it has been found necessary and convenient to combine with the telephone several admirable accessions, among which the most important are, an electric bell for calling attention, and the Microphone or "Transmitter," which intensifies the sounds and renders them louder and more distinct. This combination is shown in Fig. 36.

The telephone is hung on the hook at the lower part of the bell box. To call the attention of the central office, or of another station, a little knob is pressed, and at the same time the crank below the bell is turned briskly. This generates electric power enough to ring the bell at some other station, which

calls attention, and indicates that the person thus signaling desires to communicate.

The hook, upon which the telephone hangs, answers another important purpose; it acts as an automatic switch or cut off. The weight of the telephone holds it down, and this places its own bell in circuit, so that calls from other stations can be sounded; but when the telephone is removed, the hook flies up, and this disconnects the bell from the main line and brings the telephone itself into circuit. It can thus be seen that when the telephone is not in actual use, it is absolutely necessary that it should be left hanging on the hook, otherwise it will be impossible for another station to ring its signal bell.

The oblong plate seen immediately below the bells, form what is known as the lightning arrester. A small metallic plug accompanies each instrument, and during a thunder-storm, it should be firmly inserted in the hole between the two plates; this gives the line wire a direct communication with the ground, without running through the instrument, for there is a wire communication with the ground from the instrument. With this plug in position, no danger

need be apprehended from lightning, as the wire thus connected acts as a lightning-rod, and is as efficient for this purpose as most of the lightning-rods in use. This plug must be removed after the storm, as it is impossible to call, or use the telephone, while it is in this position between the plates.

When only one telephone is used, it is the source of considerable inconvenience, for it must be first placed at the mouth, when talking, and then at the ear, when listening, and this proves an annoying disadvantage. To obviate this, two telephones have been used, connecting with the same wire. In this case one may be placed at the mouth and the other at the ear, so that conversation and listening can go on at the same time; or, if in a very noisy place, one telephone may be placed at each ear, when listening, thus increasing the hearing capacity and shutting out other noises.

The telephone, as above described, does not require any extra battery whatever to operate it, and in ordinary cases answers every purpose. But for easy and rapid communication in noisy places, or over long lines, where the effect is liable to be diminished by

conflicting influence of other wires in the near vicinity, by what is known as induction, a more powerful

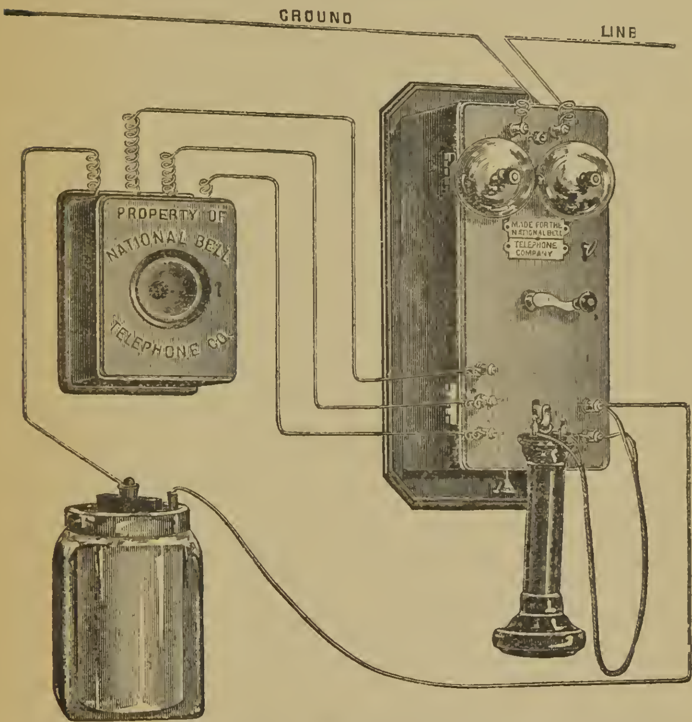

FIG. 36. THE WORKING COMBINATION OF TELEPHONE, ELECTRIC BELL, TRANSMITTER, ETC.

form of telephone is used in combination with the above described instrument. This is known as the

microphone, or,—as adopted by the BELL TELEPHONE COMPANY—as the "BLAKE TRANSMITTER." This instrument can only be used as a transmitter, and requires a telephone to hear with. It has a metallic disk similar to the telephone, which carries a carbon and platinum contact point, which are connected with a small battery and an induction coil. Its operation is similar in principle to the telephone as described, but it is much more efficient. It will transmit the faintest whisper with perfect distinctness.

Fig. 36, represents the combination described, consisting of a telephone, a magnetic call bell, and a "Blake Transmitter," with its battery; and it also shows the manner in which these instruments are connected. This forms the most complete and perfect set of instruments that have yet been used for telephonic communication.

The exact limit of distance, at which the telephone can be used, has not, as yet, been determined. It is subject to all the varying resistance and conditions, which influence the ordinary telegraph. Conversation has been carried on between St. Louis and Council Bluff, a distance of 410 miles, though the result was not perfectly satisfactory.

CHAPTER IX.

POSSIBILITIES AND PROBABILITIES OF THE FUTURE—THE TELEPHONE AND ITS PROMISES — EDISON'S OPINION—HOPE OF THE DEAF—JUDGE SIMMON'S POEM "DEAF."

This subject does not seem complete without devoting a few words to the possibilities and probabilities, which the almost marvellous scientific advances of recent times, made in reference to the transmission and recording of sound by the telephone and kindred inventions seem to give promise. The fact that the discovery of the telephone has brought to light principles heretofore unknown, and by means of which sounds may be conveyed over long distances with but little diminution of their power, has led the eager deaf to expect much help from some adaptation of it, in the near future. And when the subject is considered in its fullness, it indeed seems an expectation very capable of realization. In fact, at the present time many active and scientific minds are at work upon this very problem. That sounds may be trans-

mitted over long distances and be much intensified by the telephone and its accessory appliances is well known, but as yet, a practical application of the principle for hearing purposes in the partially deaf, has not, so far as I am aware, been accomplished.

It would be presumed that Mr. Edison, owing to his well known defective hearing, together with his knowledge of the telephone, and his other great scientific attainments, would be accepted as the particular authority on this subject. With this thought in mind, a note was recently addressed to him, asking for information on the subject. The queries were, in brief: What application had been made of the telephone for the purposes above discussed—and what, in his opinion, were the possibilities and probabilities of telephony, or any other of the recent appliances in the same direction, of ever having a practical application, as an aid to defective hearing. To this the following answer was received:

"MENLO PARK, N. J., JAN. 26th, 1881.

J. A. CAMPBELL, M.D., St. Louis. *Dear Sir:*—Your favor of 20th received. I have tried a great many experiments in the line you speak of; none have been

sufficiently satisfactory as to make a commercial introduction, which is always my object in working. I do believe that it is a possibility to utilize the results so far attained in the art of telephony, in the condition you name. Very truly,

T. A. EDISON."

The above, from such an authority, would seem to indicate that it is only a question of time, when the longing hopes of the deaf will to some degree be realized, which, although it is still a very open question, would, if it was accomplished, bring the science of acoustics, as applied to the ear, nearer on a level with that of optics, which lends such complete aid to the refractive defects of vision. This is certainly a consummation much to be wished, for it would bring back thousands from a monotonous and oftentimes almost intolerable life of isolated silence into a new world teeming with delight. To us who hear, the air is full of harmonies, which we little heed, it needs be but to stop and listen. The murmur and sigh of the summer breeze, the gurgling brook, the rustling trees, music's entrancing thrill, the sweet tones of a loved voice are to us; but the deaf man is, so to speak, in solitary confinement, and the sweet concord

of sound to him is closed. What a boon indeed would it be then, if the anticipations of telephony are realized.

The longing desires, the sensitive tenderness and deep pathos of the following poem, sung by one who knows and feels, tells its own story:

DEAF!

I often think it must be sweet,
  The notes of happy birds to hear,
When from some lofty bough they greet
  The sunrays that through clouds appear;
For I have thought that even I,
  When clouds their shadows o'er me fling,
If cheering sunlight swept them by,
  Sweet songs of gratitude could sing;
And, if my heart to song be wrought,
  When grateful thoughts my bosom fill,
What melodies—by nature taught—
  From feathered choristers must thrill.
But these to hear is not for me.
Alas! I hear not—yet I see.

I often think, when beauty's lip
  To music's soul is giving voice,
And melodies appear to drip,
  How those who catch them must rejoice;
And yet they seem the draughts to drink
  As though each one was theirs of right—
'Twould wake my gratitude, I think,
  As of the blind restored to sight.
I catch a trickle now and then;
  It thrills my heart, then melts away,

And silence then might bring me pain,
  If resignation did not say,
"Keep this reflection in thy mind,
Though deaf, thou art not dumb nor blind."

For others I can freely feel,
  And gladly strive to save them pain;
To further, if I can, their weal,
  And all my selfishness restrain.
From social throngs I often shrink—
  That else would pleasure give to me—
Because it is a pain to think
  That I, unwittingly, may be
A weary trial, and a tax
  On patience, strength, or courtesy;
And, seeming in politeness lax,
  Or gentleness or modesty.
No: my misfortune is my own,
And I will bear it all alone.

Ah! I have seen in days gone by—
  What gave me pain, but ne'er offense.
And wakened many a heavy sigh—
  A titt'ring smile at my expense.
And some of those who sport could find
  In my misfortune—me perplex—
(And who forgot I was not blind)
  Were of the fairer, gentler sex!
And I confess it pained me sore—
  They had forgotten for the time—
That though the burden which I bore
  Misfortune was, it was no crime.
I pray that heaven these may save
From pains and stings like those they gave.

I am not sensitive, I think,
  Nor does my burden bear me down.
The cup is mine and I must drink,

Why should I shudder, flee, or frown?
I can not shun it if I would,
And since 'twas sent by hand Divine,
I would not shun it if I could,
'Tis best the burden should be mine.
And so it is with all life's ills.
In fortune's frown or cold reverse,
Tis best to bear what heaven wills,
And thankful be it is no worse.
And in this thought I comfort find,
Though deaf, I am not dumb nor blind.

[From "The Welded Link and Other Poems," by JUDGE J. F. SIMMONS.]

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